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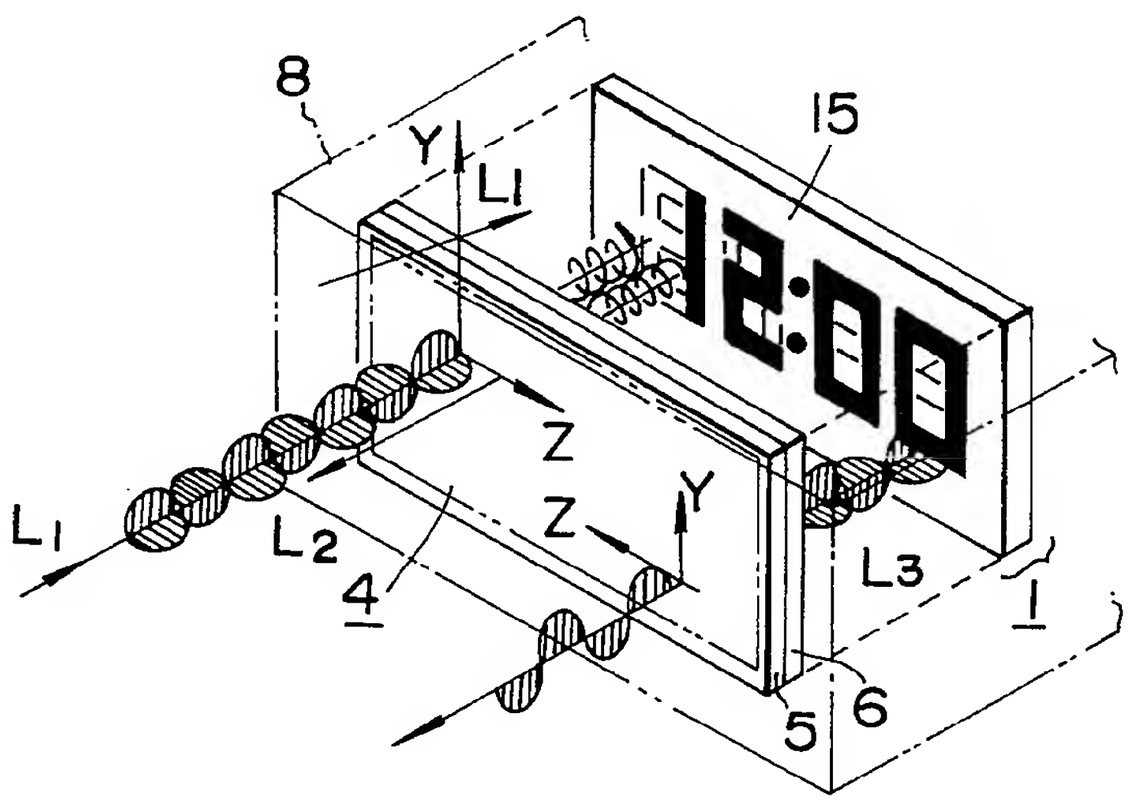
(54) **Cathodoluminescent display device**

(57) In a cathodoluminescent display device having in vacuo segments selectable to display a desired pattern, readability is improved by a circular eg. polarizing filter 4 in front of the display, so that incident light after reflection from the display surface cannot repass the filter, while emitted light is passed. The segments and background may be of the same colour to maintain readability in spite of any reflected light passing the filter.

FIG.6



GB 2 059 145 A

FIG. 1
(PRIOR ART)

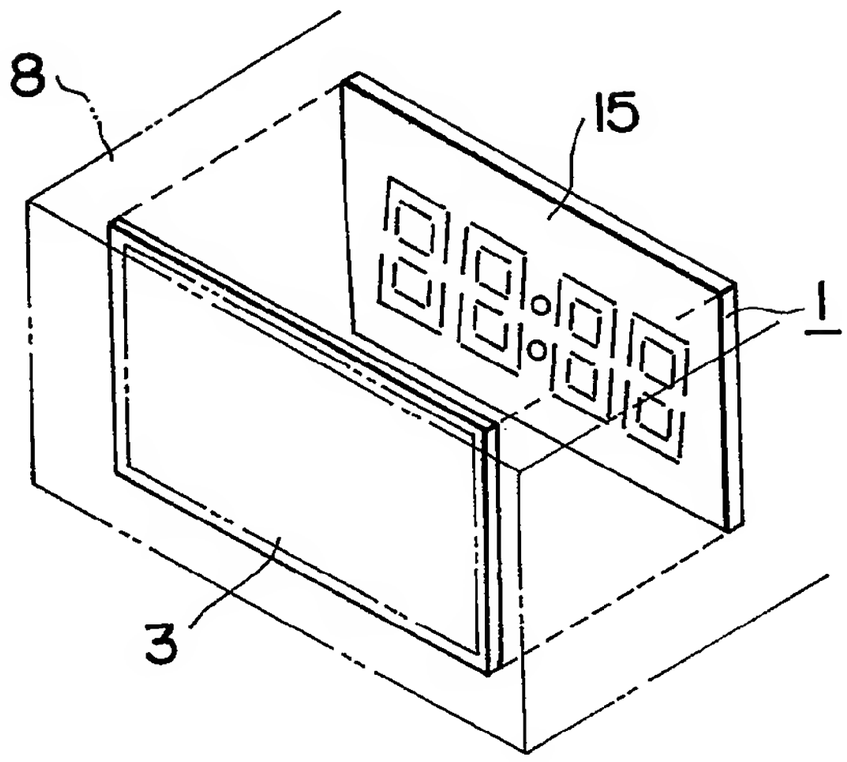


FIG. 2
(PRIOR ART)

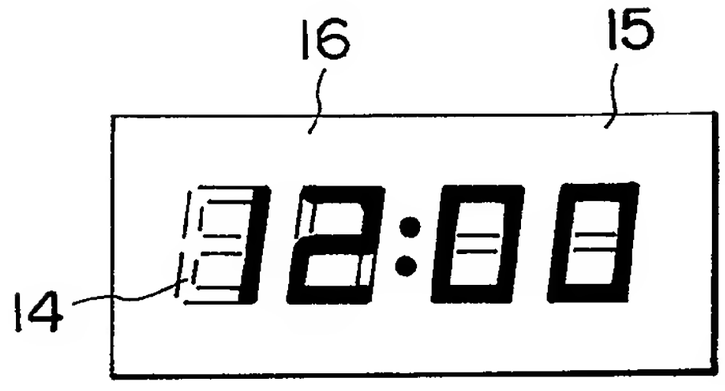


FIG. 3
(PRIOR ART)

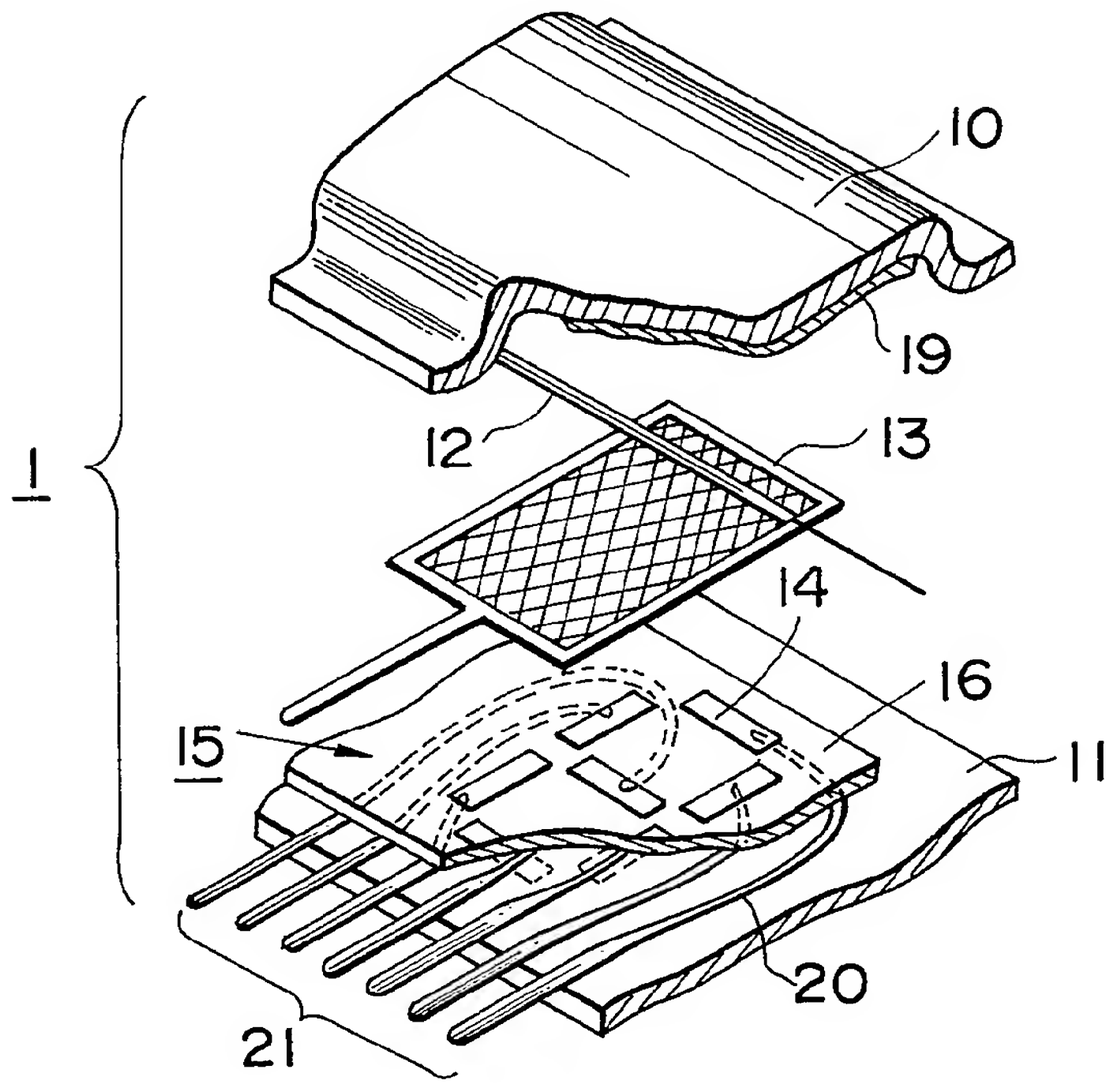


FIG. 4
(PRIOR ART)

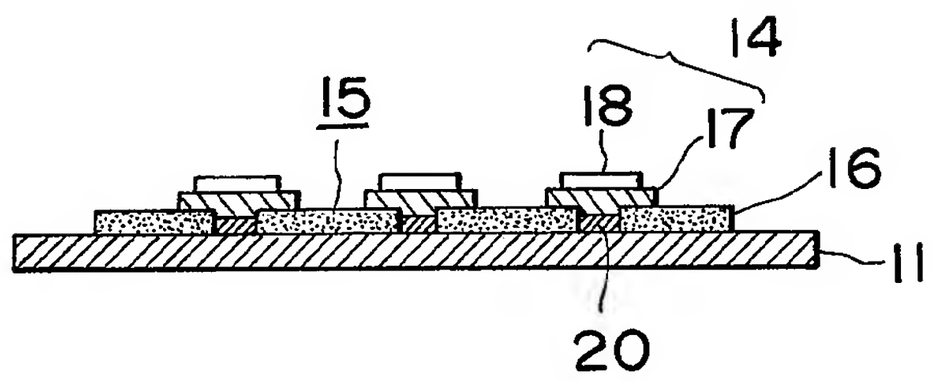


FIG. 5
(PRIOR ART)

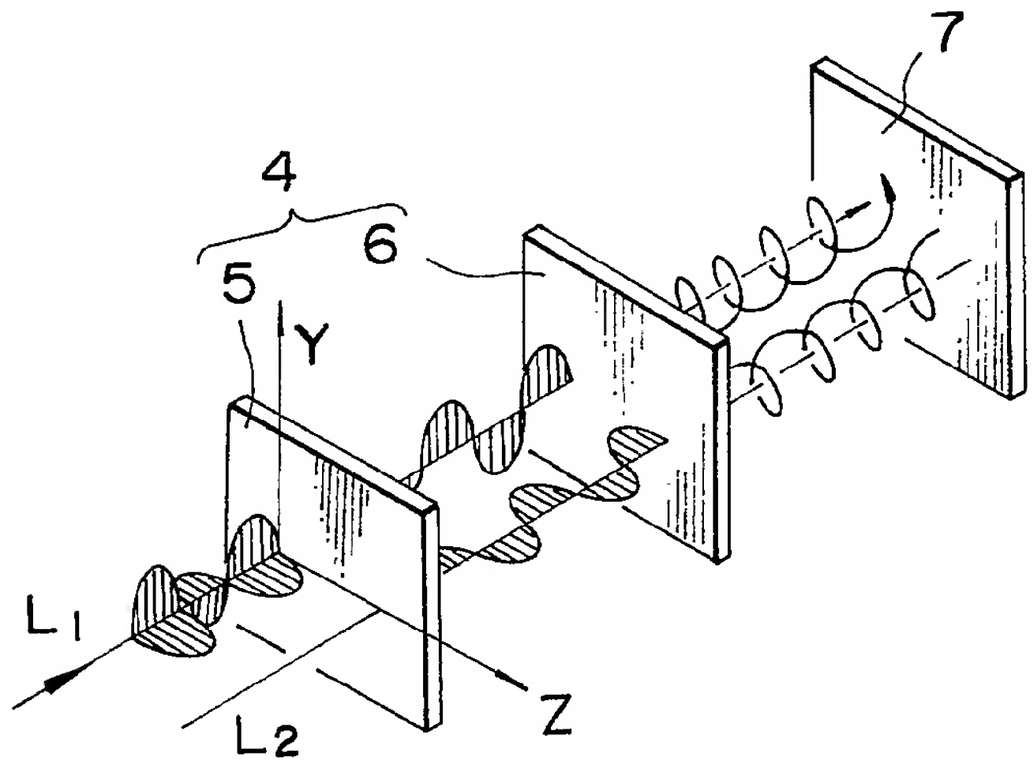


FIG. 6

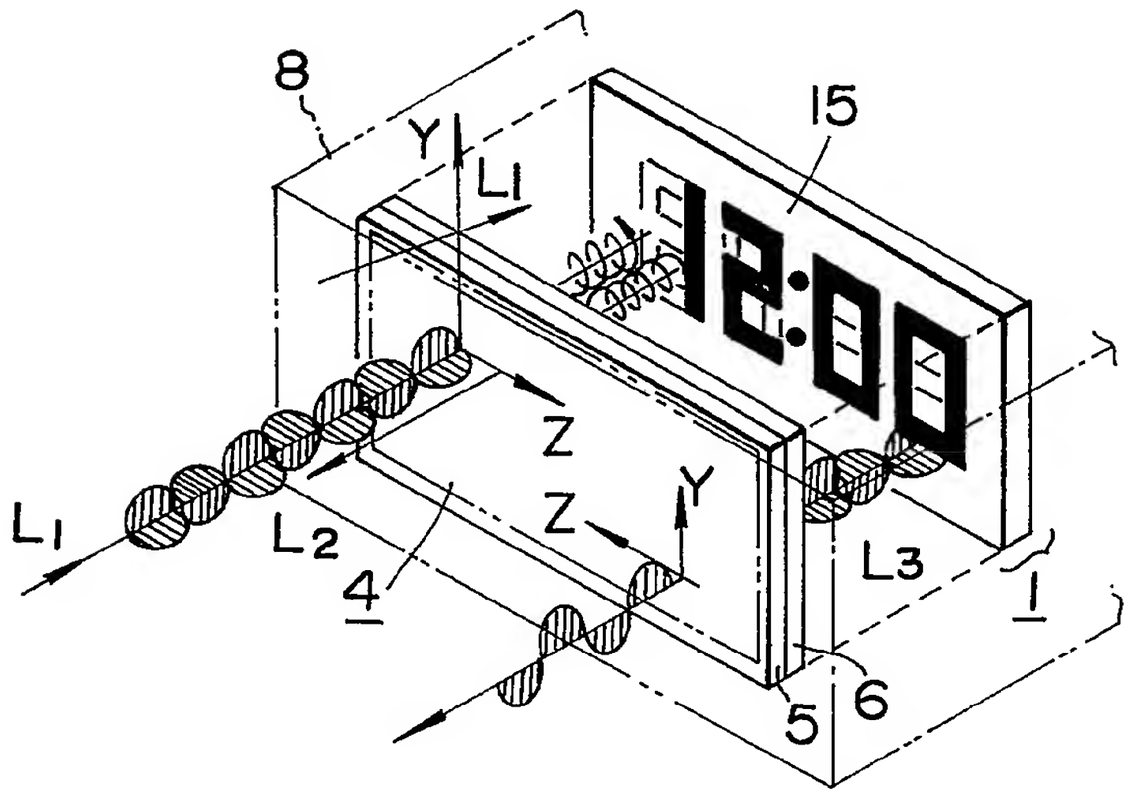


FIG. 7

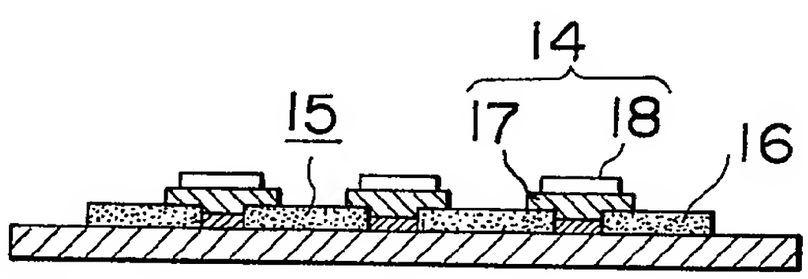
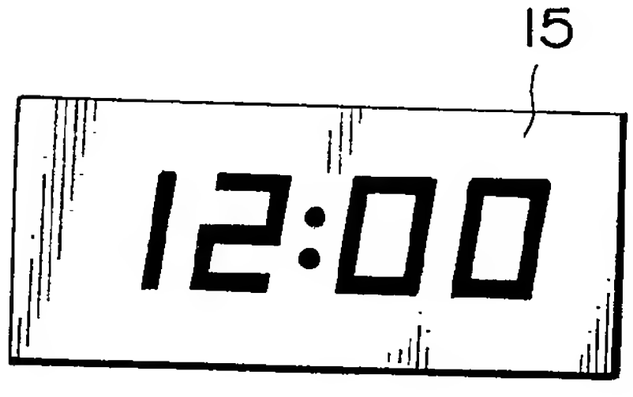


FIG. 8



SPECIFICATION

Fluorescent display device

The present invention relates to a fluorescent display device which displays characters, numerals or symbols.

Conventionally, fluorescent display devices have been widely used in electronic desk calculators, automotive vehicle instruments, digital clocks, cash registers and so on. Such fluorescent display devices each include a fluorescent display tube, a filter of a particular colour in front of the tube to allow characters, numerals, symbols, etc., appearing on the screen of the tube to be visible more easily, and a housing accommodating the tube and the filter therein. The tube includes a display surface which in turn includes a dark insulating film and in each digit position seven rod-like segments arranged in the film so as to form a figure eight. Each segment includes an electrode and a substantially white fluorescent substance made of a mixture of zinc oxide (ZnO) and zinc (Zn) deposited on the electrode so that when an electric potential is applied to the desired segments, light is emitted in the corresponding display pattern.

However, if strong external light such as sunlight is directly applied to the filter of the display device, it will easily pass through the filter. Thus when direct sunlight reaches the display surface, both the segments which are emitting light for display and the segments which are inactive will appear white because the reflected light from the active and inactive segments is relatively strong. Thus it is difficult to distinguish between the active and inactive segments and therefore the characters, numerals or symbols displayed by emitted light are difficult to read.

According to the present invention, a fluorescent display device includes a circular polarizing filter and a fluorescent display tube which includes a display surface facing the filter and with a plurality of light emitting segments in an insulating film provided on the surface. All the segments and the insulating film may be the same colour.

Incoming external light is circularly polarized by the filter, and when it reaches the display surface, it is reflected and returns to the filter. However, it cannot now pass through the filter to the outside because the filter again polarizes the reflected light. A small amount of external light leaking into the device will reach the display surface and be reflected, and, when the segments and the insulating film are the same colour, inactive segments and the background insulating film will reflect the same amount of light. The light from the activated segments and the light due to leakage pass through the filter but have different levels, so that a viewer can distinguish clearly between segments which are activated and the background.

By way of example only, an embodiment of the invention will now be described in greater detail with reference to the accompanying drawings in which:

Figure 1 is a schematic exploded perspective view of a prior art fluorescent display device,

Figure 2 is a view of a display as provided by the Figure 1 device,

Figure 3 is an exploded view of an important portion of a prior art fluorescent display tube used in the Figure 1 device,

Figure 4 is a cross-sectional view taken along line IV-IV of Figure 3,

Figure 5 illustrates the principle of a circular polarizing filter,

Figure 6 is a schematic exploded perspective view of a fluorescent display device according to the present invention,

Figure 7 is a view, similar to Figure 4, of a fluorescent display tube used in the display device of Figure 6, and

Figure 8 is a view, similar to Figure 2, of the display device according to the present invention.

In order to facilitate an understanding of the present invention, first, a prior art fluorescent display device used in a digital clock will be described with reference to Figures 1 to 4.

This device includes a fluorescent display tube 1, a filter 3 of a particular colour, provided in front of the tube to allow characters, symbols or numerals appearing on the screen of the tube to be seen easily from outside, and a housing 8 accommodating the tube and the filter. As best seen in Figures 3 and 4, the fluorescent display tube 1 includes a transparent front glass member 10, a glass base 11 behind the glass member 10, a cathode filament 12, a grid 13 and anode segments 14 accommodated between the front glass member 10 and the glass base 11, thereby constituting a triode. The inside of the envelope of the tube formed by the front glass 10 and the glass 11 is evacuated. The filament 12 is made of tungsten wire which is thin enough not to obstruct light emitted by the segments and which are covered with a thermoelectron emitting substance such as barium oxide, strontium oxide, or calcium oxide.

A display surface 15 provided on the base 11 includes an insulation film 16 and seven rod-like segments 14 forming a figure eight shape in each digit position. Each segment 14 includes an electrode 17 and a substantially white fluorescent substance or film 18 made of a mixture of zinc oxide (ZnO) and zinc (Zn). The insulation film 16 of the surface 15 except for the segments 14 is made of black ceramic material to enhance the contrast with the segments. Various combinations of the seven segments 14 display characters, numerals and symbols. The grid 13 has a fine mesh obtained by etching a thin metal plate so that characters, numerals, or symbols formed by the segments on the glass base 11 are clearly visible through the mesh of the grid 13. Further, the front glass member 10 is provided with a transparent electrically conductive film 19 on the back surface thereof, the film being supplied with a negative potential. The respective segments 14 are connected through leads 20 to terminals 21.

In operation, when the filament 12 is fed with electric current and as a result becomes hot, thermoelectrons are emitted from the thermoelectron emitting film on the filament surface. Under these circumstances, if positive potentials are applied to

the anode segments 14 and the grid 13, the thermoelectrons emitted from the filament 12 are accelerated by the electric field constituted by the anode segments 14, the grid 13, the filament 12 and the conductive film 19 on the back surface of the front glass member 10 and thus pass through the grid 13 and hit the segments 14, thereby exciting the fluorescent substance 18. Then the thermoelectrons flow through leads 20 to the terminals 21.

If the anode segments 14 or the grid 13 are at a zero or negative potential, however, the thermoelectrons do not arrive at the segments 14. Thus the fluorescent substance 18 does not emit light. Thus if a positive potential is applied to the segments 14 corresponding to a desired character, numeral or symbol, they will form a display of the desired pattern.

Now, if incident light such as sunlight is directly applied to a prior art fluorescent display device through the filter 3, it will easily pass through the filter. Thus although the segments contrast well with the dark background, the reflected light from the surfaces of the inactivated elements is sufficiently strong that it is difficult to distinguish which segments are actually illuminated, as shown in Figure 2. Therefore the characters, numerals or symbols displayed are difficult to read.

Figure 5 illustrates the principle of a circular polarizing filter as used in the present invention. The circular polarizing filter 4 is a combination of a linear polarizing plate 5 and a quarter phase difference plate 6. When natural light L_1 is applied to the linear polarizing plate 5, this plate 5 allows the light component oscillating in the Y-axis direction to pass through, but absorbs and prevents passage of the light component oscillating in the Z-axis direction. Then the light oscillating in the Y-axis direction is circularly polarized by the quarter phase difference plate 6, so that when this polarized light is reflected by the reflecting surface 7, its direction of rotation of polarization vector is reversed. Therefore the light emitted from the quarter phase difference plate is rotated through 90° from the light impinging thereon, and is thus oscillating in the Z-axis direction. Since light waves, oscillating in the Z-axis direction, are absorbed by the linear polarizing plate 5, the reflected light L_2 passing through the circular polarizing filter 4 is strongly attenuated.

In Figures 6, 7 and 8, a preferred embodiment of a fluorescent display device according to the present invention is illustrated. The same reference numerals are used to denote corresponding elements or parts throughout the drawings.

The device according to the present invention. includes a fluorescent display tube 1, a circular polarizing filter 4 disposed in front of the display tube 1 and a housing 8 accommodating therein the tube 1 and the filter 4. The insulating film 16 of the display surface 15 is made of for example white glass powder. The fluorescent substance 18 of the display surface 15 may be a white mixture of zinc oxide (ZnO) and zinc (Zn). The filter 4 includes a linear polarizing plate 5 and a quarter phase difference plate 6 in combination.

Even when external light such as direct sunlight L_1 falls on the display, the resulting reflected light L_2 will be substantially eliminated by the filter 4. If a small amount of external light L_1 arrives at the display surface 15 through the gap which may be present between the housing 8 and the filter 4, and is reflected by the display surface, the thus reflected light from inactivated segments and the insulating film 16 are substantially the same colour because the inactivated segments and the insulating film 16 are equally white, and therefore the segments emitting light for display will still be clearly distinguishable from the inactivated segments.

The light L_3 from the segments emitting light for display passes through the circular polarizing filter 4 and thus arrives at the observer as linearly polarized light.

While the present invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the scope of the present invention.

CLAIMS

1. A fluorescent display device having a display surface member on which are mounted display segments, and including
a circular polarizing filter disposed in front of the display surface member.

2. A fluorescent display device as claimed in claim 1 in which the circular polarizing filter comprises a linear polarizing plate and a quarter phase difference plate.

3. A fluorescent display device having a display surface member on which are mounted light emitting display segments and which is covered by an insulating film, wherein
the light emitting segments are, when not activated, of substantially the same colour as the insulating film.

4. A fluorescent display device as claimed in claim 3 in which each light emitting segment includes a fluorescent substance which is a mixture of zinc oxide (ZnO) and zinc (Zn), and said insulation film is formed of white glass powder.

5. A fluorescent display device as claimed in claim 3 or 4 further comprising a circular polarizing filter disposed in front of the display surface member.

6. A fluorescent display device as claimed in claim 5 in which the circular polarizing filter comprises a linear polarizing plate and a quarter phase difference plate.

7. A fluorescent display device substantially as herein described with reference to and as illustrated by Figures 6, 7 and 8 of the accompanying drawings.

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